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ORIGINAL PAPER
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DECLINE IN THE DIVERSITY OF THE DENDROFLORA OF LUBLIN ON THE EXAMPLE OF HOUSING ESTATES BUILT AT THE TURN OF THE XXTH AND XXI CENTURY

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ABSTRACT

Motives: The need to maintain species diversity in cities has been widely reported in the literature. Among other things, it promotes plant resistance to climate change, reduces susceptibility to diseases and pests, and increases the visual attractiveness of the landscape. The proper design of tall vegetation is particularly important in residential areas, where it affects the quality of life of residents. Meanwhile, the degradation of green spaces in cities has been observed.
Aim: The aim of this study was to determine the condition of greenery in Lublin's housing estates and to describe changes in its formation in different time periods.
Results: In Lublin, a decrease in the number and diversity of tree species in residential areas was observed, and it was greatest in newer neighborhoods. It is necessary to recognize this phenomenon and take measures to stop this process, e.g. by introducing new planting standards to ensure good living conditions, protect biodiversity, and create an efficiently functioning system of green areas.

Keywords: housing estates, vegetation diversity, trees, Lublin

INTRODUCTION

Housing estates are an integral part of cities. Their beginning is related to the changes brought about by the Industrial Revolution, which took place in Europe at the turn of the 18th/19th century and resulted in a growing demand for housing. Areas of residential development with high building densities and population concentrations were created (Szafrańska, 2016). In Poland, multifamily housing developed intensively in the second half of the 20th century (Kimic, 2010; Szafrańska, 2016). Modernist settlements were being built. The principles of their formation were governed by urban planning norms, which determined the manner of development and land use (Szafrańska, 2016). The settlements were distinguished by multi-story multi-family buildings loosely distributed in the surrounding green areas, which provided appropriate sanitary conditions: the possibility to ventilate the space, light to the buildings and places for recreation (Rabiej & Tomkiewicz, 2016).

The 1990s brought changes in the creation of housing developments and the organization of settlements. The public sector withdrew from the mass construction of housing, while the market opened up to private investors, helped by the liberalization of zoning laws

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and the elimination of housing norms (Kaczmarek, 2021). The emerging development takes the form of single buildings or their complexes, the location of which, dictated by the availability of free space, is often random: they appear both among existing buildings, as infill, on the outskirts of settlements, on reclaimed or newly de-landed land. Fencing off settlements has become popular (Szarek-Iwaniuk, 2019; Trzaskowska & Adamiec, 2015). Developments created by commercial investors are characterized by arbitrariness of form and aesthetics. The lack of connection between new investments and the character of settlements results in spatial chaos (Szafrańska, 2016). Developments of the early 21st century are distinguished by the lack of preservation of proportions between buildings and green areas. Most of the land is covered with paved areas, impermeable to water. Vegetation has low natural value and does not improve the quality of residential spaces (Trzaskowska & Adamiec, 2015). The areas around buildings are used for parking and transportation purposes (Ziemiańska et al., 2019). This contributes to excessive surface heating in summer and the creation of urban heat islands (Szczepanowska, 2015).

However, greenery is an indispensable component of settlement areas, which are inhabited by almost half of the urban population in Poland (Rębowska, 2000) and around the world (Zhang & Jim, 2014), a number that studies predict will increase. According to the UN, in 2030, 60% of the population will live in cities, while in 2050, 70% (Borcuch, 2020). The role of greenery is widely recognized as important (Asanok et al., 2021; Maas et al., 2009; Sobczyńska, 2014). It has natural, microclimatic, health, aesthetic and compositional significance (Sobczyńska, 2014). In urban landscape design, the use of trees is a key element. Knowledge of their benefits has increased significantly in recent decades (Wolf, 2003). Trees absorb carbon dioxide and produce oxygen, remove pollutants (Suchocka, 2013), reduce the urban heat island (Asanok et al., 2021), and regulate local climatic conditions (Garczyńska et al., 2017; Suchocka, 2013; Wolf, 2003). By affecting the quality of the environment, they contribute to the physical health and well-being of residents (Asanok et al., 2021; Borowski & Pstrągowska, 2015; Krzywnicka & Jankowska, 2021; Maas et al., 2009; Suchocka, 2013; de Vries et al., 2003; Wolf, 2003). People who live among greenery are less likely to suffer from certain diseases, including depression and anxiety disorders (Maas et al., 2009). And being among plants has the effect of reducing nature deficit among children and adolescents (Louv, 2005). Trees improve the aesthetic quality of urban spaces, mask neglected places, enhance architecture, and create spatial order (Suchocka, 2013). Large, tall trees with spreading crowns are considered the key component of neighborhood greenery in performing the indicated functions, because the ecosystem benefits provided are related to the size of the plants, understood as the assimilative area of leaves or needles (Borowski & Pstrągowska, 2015; Ely, 2009; Morgenroth et al., 2017). The decreasing share of green space in residential areas should also be compensated for by a multi-layered vegetation structure, similar to that found in open areas (Szulczewska, 2015).

Any construction, is an unavoidable interference with the natural environment, but it can be carried out responsibly, with respect for the environment. It is worth taking care to compensate for the lost natural values by introducing diverse greenery, which used to be secured by urban planning norms for residential areas (Baum, 2018).

Urban vegetation diversity is directly correlated with human well-being. It influences aesthetic appearance, guarantees resistance to pests, diseases, climate change, including urban heat island (Morgenroth et al., 2017; Shrewsbury & Leather, 2012; Sjöman et al., 2012). However, biodiversity is threatened by increased urbanization (McKinney, 2002, 2006). This topic is readily addressed in scientific studies, which mostly focus on species richness. Few of them address species composition and traits, and how they are shaped (Liu et al., 2017).

The aim of the study was to diagnose the state of greenery of Lublin's housing estates established in the second half of the 20th century and at the beginning of the 21st century. The state of high greenery was analyzed in terms of the number

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and diversity of taxa forming it and the presence of potentially large trees in its composition. Another goal was to show the changes in the formation of the greenery of settlements established in different periods of time. Looking for the reasons for the low diversity of greenery, strategic documents were analyzed (e.g., Climate Change Adaptation Plan for Lublin and Greenery Formation Standards).

MATERIALS AND METHODS

For the purpose of the study, an inventory of woody plants of three Lublin housing estates was carried out in 2020–2022. Their selection was guided by the size of the area, similar location in the mid-western part of Lublin (Fig. 1), habitat conditions, time variation of emergence. These include the Skarpa Estate, where the survey covered an area of 27.338 ha, the estate on Kryształowa Street with an area of 26.973 ha, and the estate on Gęsia Street with an area of 24.332 ha. The area of the sites was measured using Geoportal tools (2022). The oldest is the Skarpa Estate, which was built in the 1970s–90s and is located in the North Czuby district. The buildings here were erected using large-panel technology. They are accompanied by extensive green areas (Osiedle Skarpa, 2022; Szulc & Mącik, 2017). Settlement areas on Gęsia Street and Kryształowa Street are located

Fig. 1. Location of the residential neighborhoods selected for the study against the background of Lublin

Source: own elaboration based on Geoportal Miejski (2024).

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in the Węglin Południowy district. These are developer developments. Buildings began to be constructed here after 2010 (Investmap, 2022a; b). Most of them are finished and inhabited, and the surrounding areas are landscaped, including in terms of plantings.

A dendrological inventory was carried out on each of the estates using the march method, which consists of a physical inventory of trees, shrubs and climbers. The botanical nomenclature is given after Seneta et al. (2021). For each settlement, the number of individuals of woody plants, the number of species and genera represented were determined. Large trees were also distinguished. Species that could potentially reach at least 10 m in height were considered as such (according to Seneta et al., 2021). The number of trees, species and genera were determined for them.

Planning documents for residential areas and urban greenery were analyzed. The following were considered: provisions on greenery in the 1974 Urban Planning Normative (Dąbrowska-Milewska, 2010), the Polish Architectural Policy (2011), the Regulation of the Minister of Infrastructure of April 12, 2002 on the technical conditions to which buildings and their location should conform, the Plan for Adaptation to Climate Change of the City of Lublin to 2030 Draft (2018), Standards of shaping and maintaining greenery in Polish cities: Lublin (Biuro Miejskiego Architekta Zieleni UM Lublin & Durlak, 2022), Krakow and Wroclaw (Maliszewska, 2022), Lodz (Dworniczak & Reda, 2021), Szczecin (Kubus et al., 2020), Warsaw (Borowski et al., 2016).

RESULTS

In the study areas, 9189 woody plants were inventoried. On the Skarpa Estate there were 4027 woody plants, they represented 109 species from 65 genera. On Kryształowa Street, 2875 individuals belonging to 86 species from 52 genera were inventoried, while on the estate on Gęsia Street: 2287 individuals from 90 species and 59 genera. There are fewer species and genera of woody plants in the younger settlements (Fig. 3), fewer individuals were recorded (Fig. 2).

Among the most numerous genera on the Skarpa Estate were: *Robinia, Acer, Prunus, Malus* and *Tilia* (Fig. 4). The most common species were: black locust *Robinia pseudoacacia* L., ashleaf maple *Acer negundo* L., cherry plum *Prunus cerasifera* Ehrh., norway maple *Acer platanoides* L. The most numerous genera on the Kryształowa Street estate were *Juniperus*, *Thuja*, *Spiraea*, *Acer*, *Betula*, *Prunus*, and *Sorbus* (Fig. 5), while the dominant species were american

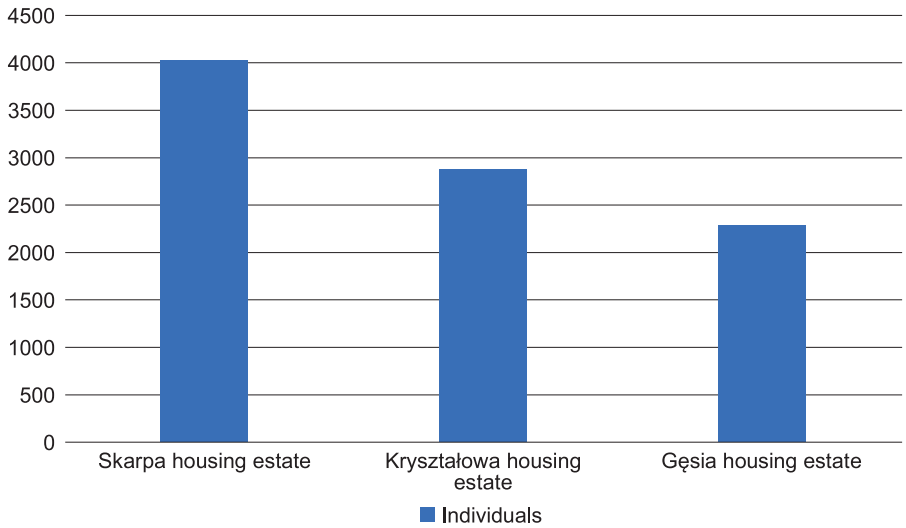

Fig. 2. Quantitative share of dendroflora (trees, shrubs, climbers) in selected residential areas of Lublin – individuals
Source: own elaboration.

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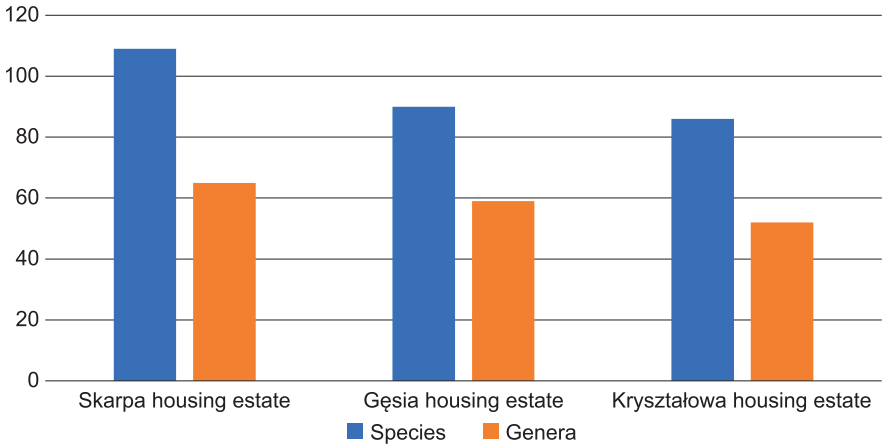

Fig. 3. Quantitative share of dendroflora (trees, shrubs, climbers) in selected residential areas of Lublin – species and genera
Source: own elaboration.

arborvitae *Thuja occidentalis* L, Japanese spirea *Spiraea japonica* L. f., common silver birch *Betula pendula* Roth and Norway maple *Acer platanoides* L. The most common genera at Gęsia Street included: *Thuja, Juniperus* and *Acer* (Fig. 6). The dominant species, however, were American arborvitae and varieties of *Thuja occidentalis* L. and Norway maple *Acer platanoides* L.

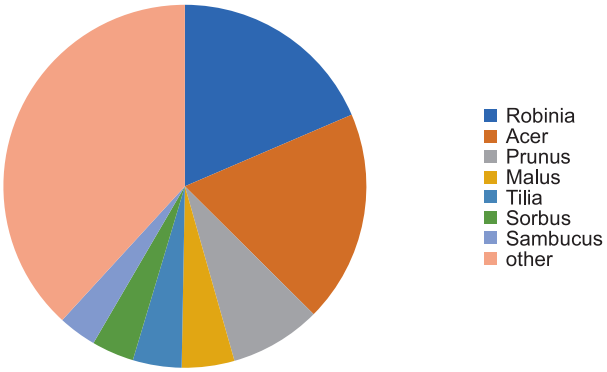

Fig. 4. Dendroflora of the Skarpa Estate – dominant genera
Source: own elaboration.

Analysis of the dendroflora of the estates in the categories of trees, shrubs and climbers shows that on younger estates the number of species and types of trees decreases (Fig. 8), and the number of specimens also decreases significantly (Fig. 7).

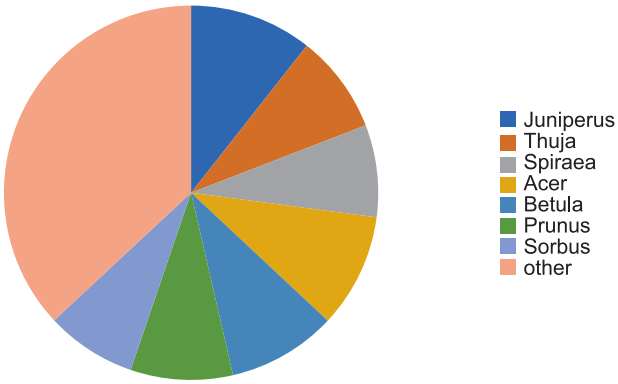

Fig. 5. Dendroflora of the Kryształowa Estate – dominant genera
Source: own elaboration.

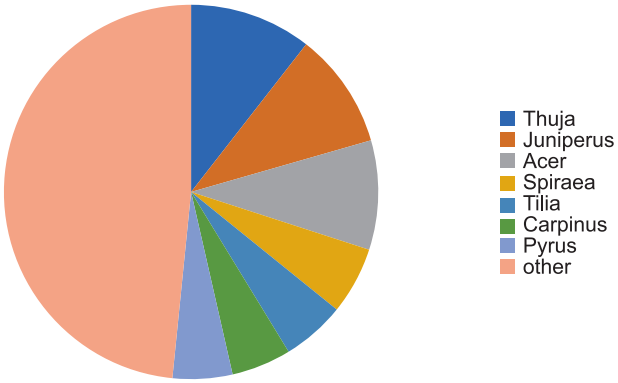

Fig. 6. Dendroflora of the Gęsia Estate – dominant genera
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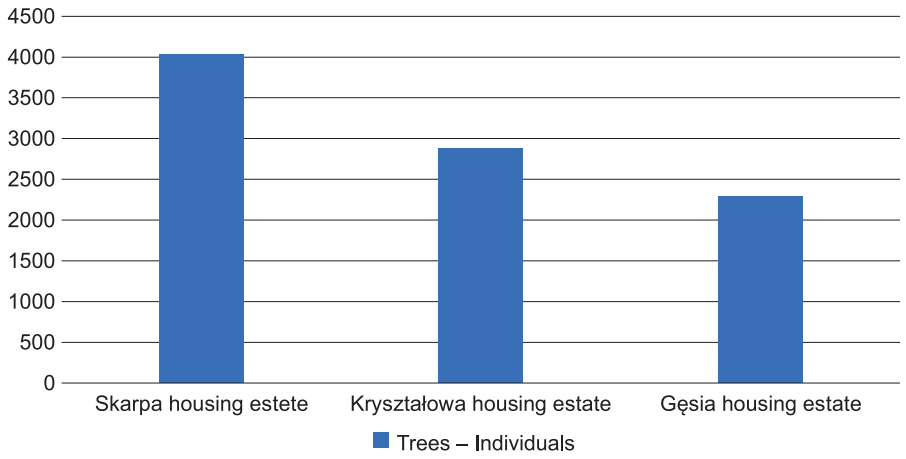

Fig. 7. The number of trees in the surveyed residential areas – individuals
Source: own elaboration.

The opposite is true for shrubs, where on younger estates the number of species representing them decreases (Fig. 10), but the number of specimens increases (Fig. 9). In the case of vines, an increase in the number of species, genera, as well as specimens is evident on younger estates.

The number of trees reaching at least 10 meters in height totaled 4771. In the Skarpa Estate, 2954 trees from 53 species and 29 genera were inventoried. On Kryształowa Street, 1003 specimens belonging to 42 species from 27 genera were found, while on Gęsia Street, 814 trees representing 90 species from 59 genera were found.

Among the inventoried trees on the Skarpa Estate, 1131 were native specimens belonging to 25 species, 882 native trees of 18 species were counted on the Kryształowa Street estate, and 528 specimens of 19 species were counted on Gęsia Street. The survey showed that in the group of woody plants, which includes trees, shrubs and climbers, the number of species has decreased: in the youngest estates, it has decreased by about 20% compared to the number recorded in the greenery of the older Skarpa Estate. The number of species of large trees has also declined, their number decreasing by 7–17%.

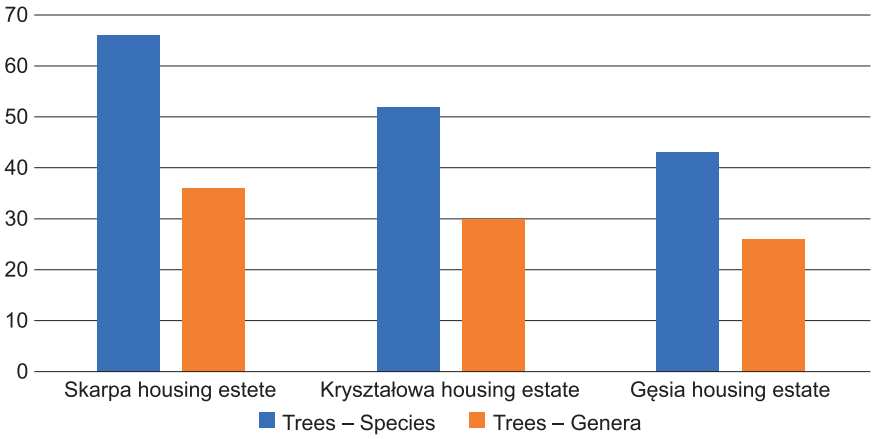

Fig. 8. The number of trees in the surveyed residential areas – species and genera
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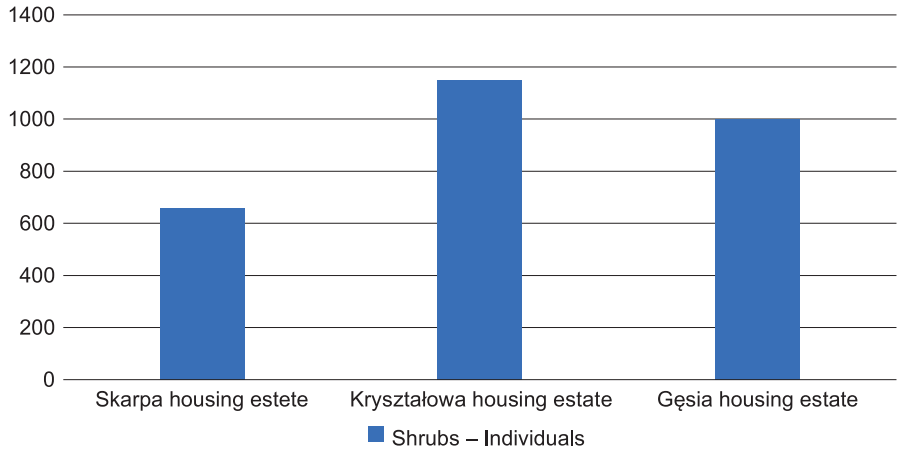

Fig. 9. The number of shrubs in the studied residential areas – individuals
Source: own elaboration.

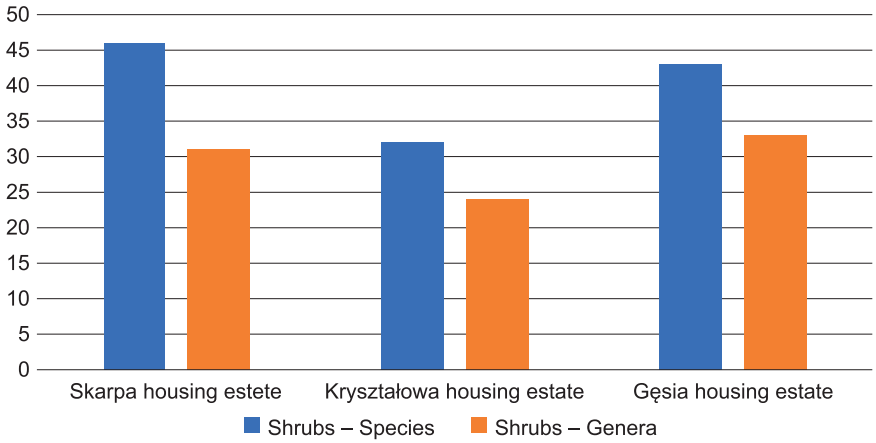

Fig. 10. The number of shrubs in the studied residential areas – species and genera
Source: own elaboration.

An analysis of greenery standards developed for Polish cities shows that they provide guidelines for implementation and maintenance work on urban trees, and can be enriched with suggestions for plant species selection. However, they do not indicate the principles of shaping neighborhood greenery or species preferred for the climatic benefits provided or ecological importance. Their observance is not mandatory. Also, the analyzed strategic documents do not indicate how settlements should be shaped in terms of planting plants, they say in general that greenery in cities is needed, it should be taken care of, new green areas should be developed, trees should be planted as a valuable component of them.

DISCUSSION

Similar changes to the young settlements in Lublin are observed in many places in Poland (Garczyńska et al., 2017; Kronenberg, 2012; Łakomy, 2011) and around the world (Jim & Zhang, 2015; Sjöman et al., 2012; Wang et al., 2014). Biodiversity is declining at global, regional and local scales (Grimm et al., 2008). This phenomenon is registered in urban areas, where land previously covered with vegetation is being developed and paved over (Kimic, 2010; McKinney, 2006; Trzaskowska, 2020). Such activities promote the formation of the urban heat island phenomenon. As reported by Kuchcik et al. (2019) and Kuśmierz

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et al. (2018), it occurs to an intensified degree in areas of high, compact development in urban centers, as well as in densely built-up neighborhoods with a small share of biologically active area (less than 25%). According to data from the map of land surface temperatures in the Lublin Functional Area (Diagnosis for the Climate Change Adaptation Plan, 2019), in Lublin, the highest maximum temperatures are recorded in the city center and also cover the areas of all the surveyed settlements: Skarpa, on Kryształowa Street and on Gęsia Street. The areas of the studied settlements have also been classified as a zone of very high risk associated with climate change (Kuśmierz et al., 2018). As areas where adverse climatic impacts are recorded, these areas require intensified mitigation efforts. Szczepanowska (2015) in mitigating the urban heat island points especially to the significant function of trees and Kuchcik et al. (2019) on the extent of green cover at 42–45%. The low number of trees also reduces the quality of the human living environment (lack of recreational areas, opportunities for contact with nature), reflects negatively on the health of residents (increase in summer temperatures), especially the sick, elderly and children (Kronenberg, 2012; Kuśmierz et al., 2018). On the other hand, it is the high level of biodiversity of green spaces in cities that is associated with physical and mental well-being of people (Carrus et al., 2015; Morgenroth et al., 2017; Nielsen et al., 2014).

Many authors report that the number of trees in urban green spaces is decreasing (Garczyńska et al., 2017; Kronenberg, 2012; Suchocka, 2013). This phenomenon has been well described in the United States, where it affects cities such as New Orleans, Houston, Albuquerque (Nowak & Greenfield, 2012), or the state of California (McPherson et al., 2016). This is also confirmed by our research, which showed that the number of trees, shrubs and climbers of the youngest estates is about 30–40% lower compared to the older Skarpa Estate, while the number of trees reaching at least 10 m in height is as much as 70% lower in the youngest estates compared to the Skarpa Estate. These data also coincide with a study by Trzaskowska and Adamiec (2015a), who point out that development estates lack places to plant trees that grow to large sizes. This seems to be the primary and main reason for the phenomenon described here.

Another disturbing phenomenon is the change in the species composition of urban greenery: trees that can reach considerable heights, develop elaborate crowns, form a large mass of foliage and provide many environmental benefits, such as the maples *Acer* spp. noted in the Skarpa Estate, lindens *Tilia* spp., rowans *Sorbus* spp., or Siberian crabapple trees *Malus baccata* (L.) Borkh., are being replaced on development estates by numerous planted shrubs, among which junipers *Juniperus* spp., arborvitae trees *Thuja* sp., and brideworts *Spiraea* spp. dominate. The trend of replacing large trees with smaller forms is also seen in other cities, with, as in Lublin, the trend being associated with new developments (Britt & Johnston, 2008). The greenery of real estate development projects presents little natural value and does not contribute to the creation of high-quality spaces for residents; it is aimed only at performing representative functions (Trzaskowska & Adamiec, 2015). Higher quality greenery performing multiple functions (climatic, ecological, natural) is characterized by older settlements, within which there is a multi-layered structure of vegetation with a high proportion of old trees (Szulczewska, 2015).

A feature of urban greenery is the presence of introduced species in its composition, the number of which is increasing from suburban areas towards the center (McKinney, 2002). The use of non-native plants is related to both their ornamental qualities and their increased resistance to many of the unfavorable conditions found here. Non-native species in cities compete with native vegetation, and their large contribution to ecosystems can impair environmental benefits (McKinney, 2006; Nielsen et al., 2014). An unfavorable phenomenon has been observed in Lublin, the number of native trees in new housing estates is 22–53% less than the Skarpa Estate, while the number of native species in new housing estates has decreased by 24–28%. The reduction in the number of native trees is also confirmed by studies

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by Bertin (2002), Chocholouskova and Pysek (2003), McKinney (2006).

The deterioration in the quality of urban greenery in Poland is related, among other things, to the abolition of urban planning norms that functioned in the past, which defined the minimum area of greenery per inhabitant as 8 m^2, and the minimum total area allocated for greenery as 50% of the site. Currently, the rate of greenery in residential areas has been limited to 25% of the biologically active area, which also includes the grassed roofs of underground garages (Regulation of the Minister of Infrastructure of April 12, 2002 on the technical conditions to be met by buildings and their location; Schneider-Skalska, 2004; Dąbrowska-Milewska, 2010; Kłopotowski, 2016). This can be improved by introducing new greenery standards. Measures that develop tree management programs and lists of taxa recommended for planting are already introduced by many cities around the world (Borowski & Pstrągowska, 2015; McPherson et al., 2000) and in Poland (Borowski et al., 2016; Dworniczak & Reda, 2021; Muras, 2016). In addition, Jim (2002, 2001, 2000) points out that the situation of urban tree planting can also be improved through measures such as: reorganizing greenery management institutions, coordinating and clarifying their responsibilities to increase the efficiency of their activities, establishing appropriate legal instruments to manage and protect trees. According to Jakubowski (2013, 2018), Bergier et al. (2018) and Jeleński (2018), it is important to conduct education and encourage local communities and NGOs to participate in greenery management, introduce tree planting and care programs aimed at increasing the quantity, quality and diversity of trees, develop local species selection guidelines that take into account native trees and species that reach large final sizes. Morgenruth et al. (2017) remind us that biodiversity should be promoted at the species, age and spatial levels, while urban tree inventories are helpful in its management. As Jim (2002) and Bożętka (2008) point out, for the preservation of good condition of trees in cities, it is also important to take care of the connections between the greenery elements inside the city and the greenery of suburban areas. It is important to preserve forest enclaves and remnants of natural greenery in cities, as well as the high content of natural elements in green structures penetrating the urban fabric and connecting the greenery of the city with the greenery of the outside world. The creation of an urban greenery system linked to the natural environment will help increase its quality and strengthen its beneficial impact on the city space.

The indicated guidelines and good practices of greenery planning and management should provide a premise for Polish cities. Their implementation will be helpful in increasing the number and improving the quality of green areas in urban areas.

CONCLUSIONS

Over the course of 40 years, unfavorable changes in the formation of the tall greenery of residential areas of Lublin are evident. Both the number of species and woody plants is decreasing. Negative changes are noticeable in the quality of greenery: formerly planted tall deciduous trees are being replaced by small shrubs, among which coniferous species have a significant share. The two younger estates were dominated by arborvitae trees *Thuja* sp., junipers *Juniperus* spp. and brideworts *Spiraea* spp. These are plants that reach small sizes and are therefore suitable for use in small garden settings. However, they are not beneficial in mitigating climate change (the occurrence of an urban heat island) in settlement areas.

The estate dendroflora includes fewer and fewer native species, which are being replaced by introduced taxa. Too high a proportion of them in the greenery can negatively affect the amount of beneficial environmental impacts delivered.

In modern cities, it is necessary to strive to halt negative changes and properly shape neighborhood greenery. The introduction of diverse plant forms, a significant proportion of tall deciduous trees, diversification of species composition and attention to native species, planting of plants adapted to climatic conditions, are measures that provide an opportunity for the vegetation cover, providing numerous

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environmental benefits, to contribute to mitigating the phenomenon of urban heat island and creating a good quality living environment for residents. To achieve this, it is necessary to introduce multifaceted measures based on guidelines being developed around the world, among which it is worth mentioning the introduction of new greenery standards, the introduction of specific data into strategic documents, educational activities, tree planting and care programs, or the development of local greenery species selections that take into account the opinions of local communities.

Author contributions: authors have given approval to the final version of the article. Authors contributed to this work as follows: E.T. developed the concept and designed the study, E.T. and J.R. collected the data, J.R. analysed and interpreted the data, J.R. prepared draft of article, E.T. and J.R. revised the article critically for important intellectual content.

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